No Decline in Salamander (Amphibia: Caudata) Populations: A Twenty-Year Study in the Southern Appalachians

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ABSTRACT—Identical observations, conducted 1-4 times per year for 15-20 years at two locations in the southern Appalachians, have yielded quantitative data on populations of six species of salamanders. Although the numbers have fluctuated for various reasons, there has been no trend in the numbers of any of the species. The "world-wide decline of amphibian populations" has not occurred in the two localities studied.

Recently, much attention has been given to a decline in many populations of amphibians (Barringer 1990, Blaustein and Wake 1990, Phillips 1990). There is a suggestion by some authors that there is a general cause for a supposed "world-wide" decline. We do not deny that many amphibian species have decreased in abundance. Among the causes that have been suggested are acid precipitation (Harte and Hoffman 1989, Beebee et al. 1990) and ultraviolet increase due to ozone depletion (Barringer 1990, Blaustein and Wake 1990, Phillips 1990). The same authors have considered overcollecting and rejected it as a general cause. Habitat destruction is also widely mentioned. The last cause is common to all species, except for some pioneering ones, and would not apply only to amphibians. The situation is regarded by many herpetologists as very serious, so much so that the World Conservation Union (IUCN), Species Survival Commission, has activated a Declining Amphibian Populations Task Force. This group has established local subgroups throughout the United States and elsewhere in the Americas to promote research on the problem.

If there has been a general cause for the decline in amphibian populations, all amphibian populations should be involved; if they are not, the original claim of a "world-wide decline" must be modified, either by eliminating some taxonomic groups, some ecologically distinctive species (e.g., those lacking aquatic stages), or some geographic regions. Study of apparently exceptional cases might give clues to the causes of declines that have been observed.

METHODS

In September 1971 and 1972 N.G.H. and classes from the University of Michigan studied the distribution of the colors of

Plethodon hybrids along altitudinal transects at the Coweeta Hydrologic Laboratory, near Franklin, North Carolina, and in 1972 they also recorded the ecological distribution of four species of *Desmognathus* (Hairston 1973). In 1973 and 1974, N.G.H. studied a zone of intergradation between two forms of *Plethodon jordani* and the altitudinal replacement of that species and *P. glutinosus* at Heintooga Overlook in the Great Smoky Mountains National Park near the junction of the Balsam Mountains and the Great Smoky Mountains in Haywood and Swain counties, North Carolina. The name *glutinosus* is controversial for this form; Highton (1983) proposed the name *teyahalee*, which we believe to be misapplied (Hairston 1992).

N.G.H. also continued the observation of *Plethodon* hybrids at Coweeta in 1974. Beginning in September 1976 and for each year thereafter, we have led one to four (usually two) undergraduate classes of 15 students each to both localities and made carefully repeated observations of the same kind.

At Heintooga, the students were instructed to capture 10 *Plethodon*, return with them to the vehicles, and examine the animals' cheeks for the amount of red color; specimens were then returned to the forest. The exercise was repeated at 3.2, 6.4, 9.7, 11.3, and 13.7 km along the National Park Service road to Round Bottom Camp Ground, with species identifications made at the last two stops. The elevations ranged from 1,600 m at the start to 1,350 m at the last stop. At Coweeta, the same exercise was carried out at five elevations, starting at 686 m and continuing up at 91.5-m intervals. We and the students evaluated the amount of red on legs and the amount of white on sides and back. Both of these exercises were performed at night, beginning at dark. The *Desmognathus* exercise involved the students collecting specimens and noting identification of each and the distance from nearest surface water to where they were found. The exercise requires a period of 2-2.5 hours in the afternoon.

Each class exercise on *Plethodon* began at dark (2000 hours) and ended at approximately the same time each night (2330 hours at Heintooga and 2230 hours at Coweeta). The *Desmognathus* exercise began at 1230 hours and ended at approximately 1430-1500 hours. Thus, there has been no tendency to expend extra effort to observe the same number of salamanders.

RESULTS

There has been no consistent trend in the number of individuals of any of the seven populations over the 15-20 years of the study (Figs. 1-3). All seven series show fluctuations greater than more exact studies showed over shorter periods near the sites reported here

(Hairston 1987). There are several known causes for the fluctuations, which occurred over much shorter intervals than the mean generation times (5-10 years) for the different species (Hairston 1987). Some were due to cold weather, when *Plethodon* tend to remain underground (first class, September 1981); others were due to exceptionally enthusiastic classes (September 1977). None of the fluctuations in numbers observed can be attributed to a real change in the number of salamanders actually present. The mean generation time for *P. jordani* is 9.8 years and for *glutinosus* it is at least a year longer (Hairston 1987). Thus, fluctuations in numbers seen at shorter intervals do not represent real changes.

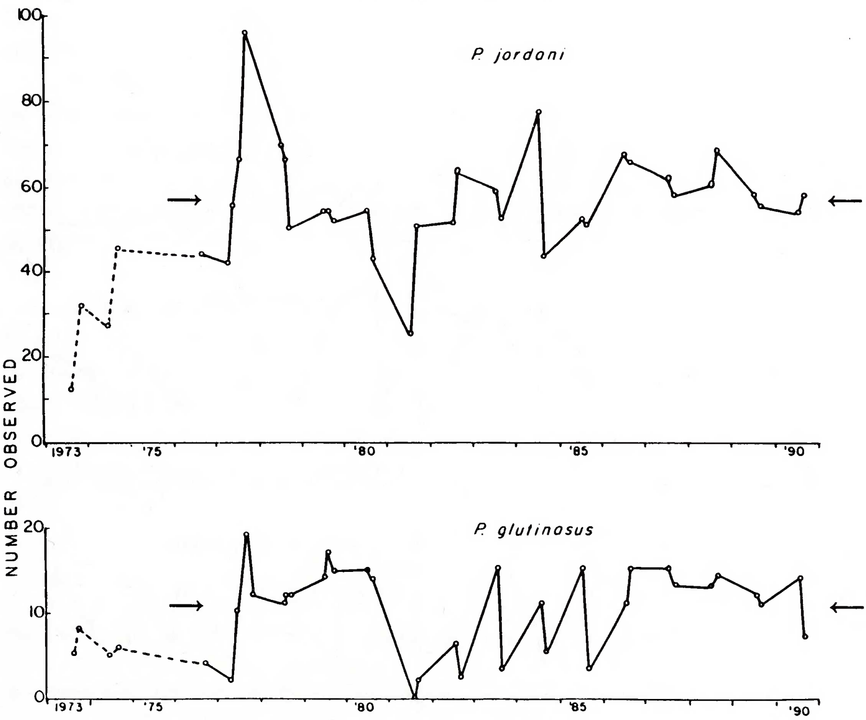

Fig. 1. Population history of *Plethodon jordani* and *P. glutinosus* in the Heintooga locality, as shown in numbers observed by successive classes from 1976 to 1990. Broken lines represent preliminary observations not exactly equivalent to class date. Arrows show means of all class data; standard error not given because the counts might not be independent because of the longevity of individual salamanders and the likelihood that at least some of the same ones were observed on successive class exercises.

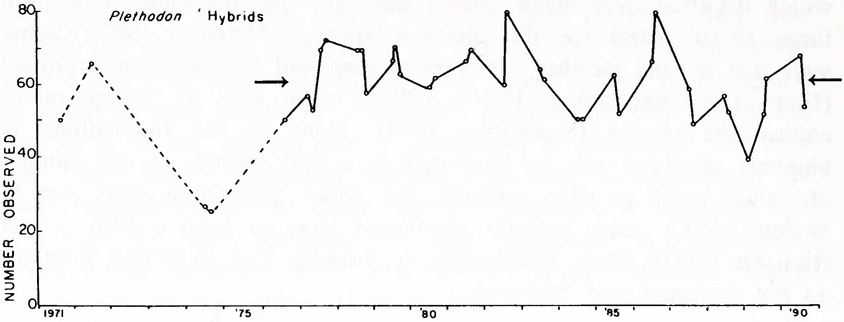

Fig. 2. History of the *Plethodon* population at Coweeta. Symbols are the same as in Figure 1.

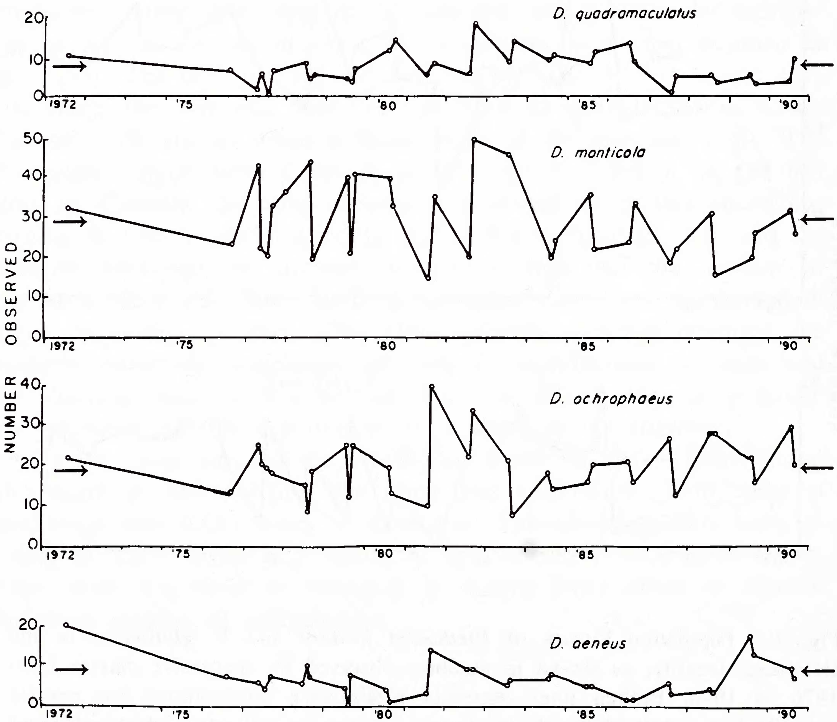

Fig. 3. Population histories of four species of *Desmognathus* at 686-m elevation, Coweeta Hydrological Laboratory. Symbols are the same as in Figure 1.

DISCUSSION

As far as we know, this is the longest series of continuous quantitative observations on any amphibian populations. Other multiple-year studies include 13 years for Savannah River Ecology Laboratory studies (Pechmann et al. 1991) and the same duration for *Taricha rivularis* in California (Twitty 1966). In the former, changes could be explained by drought, and the latter was completed long before the supposed general decline of amphibian populations.

Our observations bear on some of the suggested causes for long-term declines in amphibian populations. There is considerable evidence that the observed dieback and decline of spruce-fir forests in the southern Appalachians is due to atmospheric pollution (Bruck 1988, Dall et al. 1988, Zedaker et al. 1988). As the salamander populations have remained essentially in steady states, acid rain and ozone depletion cannot be universal causes of all declines in amphibian populations.

As the great majority of records of population declines are based on anecdotal evidence, we remain skeptical of the generality of these declines until similar long-term records are produced. We are also convinced that over-collecting by biological supply companies and by some herpetologists has been underrated as a possible cause of observed declines.

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